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PROCESS SELECTION SUMMARY

SNG FROM COAL

FOR

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DRAVO CONTRACT NO. CPD-7024
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Dravo

CHEMICAL PLANTS DIVISION
ONE OLIVER PLAZA, PITTSBURGH, PA. 15222

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Dravo

PROCESS SELECTION SUMMARY
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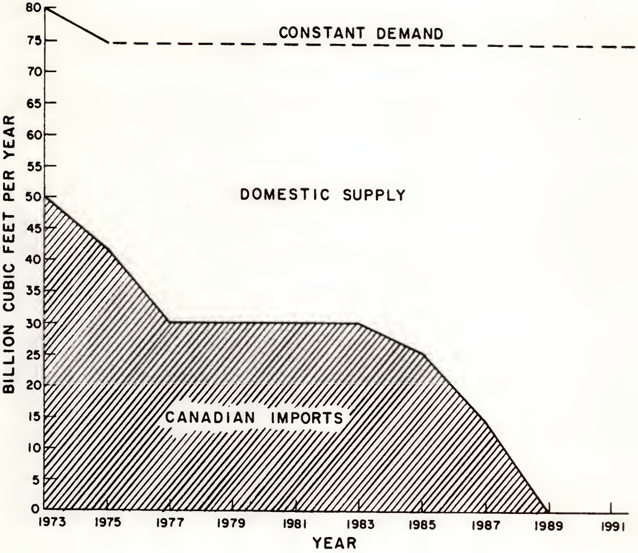
A summary of the results of the coal gasification Process Selection Study performed by Dravo Corporation for the Montana Trade Commission is presented herein.

1.0 Background

Montana is considering coal gasification for the manufacture of synthetic natural gas (SNG) because of the anticipated curtailment of Canadian imports. In 1975, of the 75 billion cubic feet of total demand, 42 billion cubic feet were imported from Canada. By 1989, the Canadian imports will be reduced to nil, and the demand must be supplied from other sources. (See figure attached.)

2.0 Preliminary Screening

In this study, 21 coal gasification processes were considered. These included both first and second generation processes. The processes were subjected to a preliminary screening to assess their suitability with respect to Montana lignite coal and the schedule requirements of the state of Montana. Thirteen processes were eliminated on the basis of the schedule requirements alone, many of these processes being in early stages of development. The surviving eight processes



Projected Montana Supply/Demand of Pipeline Gas

2.0 Preliminary Screening (Cont'd.)

passed the Montana lignite criterion and were therefore selected for a detailed comparative evaluation. They are:

1. Babcock & Wilcox
2. CO_2 Acceptor
3. COGAS
4. HYGAS
5. Koppers - Totzek
6. Texaco
7. Winkler
8. Lurgi

3.0 Final Evaluation

For the evaluation, all the processes were designed to produce 150 million standard cubic feet per day of SNG (925 Btu/SCF, HHV, dry) and ammonia synthesis gas equivalent to 1000 tons per day of ammonia. Dravo Corporation was provided this capacity as the basis for this evaluation. The SNG would have a moisture content of a maximum of 7 pounds per million standard cubic feet, and it would be delivered into the pipeline at 1000 psig. The plants were designed on a grass roots basis, and the site assumed was the Glasgow Air Force Base. The feed coal was assumed to be Montana lignite with the following

3.0 Final Evaluation (Cont'd.)

specifications:

Type:	Circle West Lignite, "R" bed
Mine Location:	40 miles, S/SE of Glasgow Air Force Base
Size, as received:	2" x 0", washed
Percent moisture:	35.02%, as received
Ash:	6.86%, as received
Heating Value:	6,894 Btu/lb., as received 10,610 Btu/lb., dry

As part of the evaluation, material and energy balances were prepared for the processes, and the overall thermal efficiencies were established. Engineering, procurement and construction schedules of the plants were also prepared. The processes then were qualitatively evaluated for suitability to Montana lignite coal, degree of development, technical risk, mechanical reliability, operability and start-up, flexibility and turn-down, gasifier scale-up requirements and environmental considerations. To assess the economic viability of the processes, capital investments and operating costs were also estimated. Using the utility financing method, the product gas costs were calculated for all processes. The following economic parameters were used:

- Debt: Equity Ratio = 75:25
- Interest on Debt = 9%

3.0 Final Evaluation (Cont'd.)

- Return on Equity = 15%
- Federal Income Tax = 48%
- 20-year life, straight-line depreciation

Estimates were made of the start-up costs, working capital, manpower requirements, supplies and overhead costs.

4.0 Assignment of Point Ratings

In order to compare the processes on a quantitative basis, the processes were rated for several criteria. The technical evaluation ratings were compiled first. Then, for the overall evaluation, point ratings were also assigned for thermal efficiency and economic, financial and environmental criteria. The total point ratings were then consolidated for each process.

The technical criteria and their relative importance were selected by Dravo Corporation. The other criteria and their relative importance were selected by the Montana Trade Commission.

5.0 Conclusions

The results of the evaluation are summarized in the attached table.

5.0 Conclusions (Cont'd.)

The technical evaluation ratings show that Lurgi, Koppers - Totzek and Winkler have the higher ratings. This is as expected because they are commercially proven processes. However, in the overall evaluation, the relative merits of the HYGAS and CO_2 Acceptor processes become apparent mainly because of their high overall thermal efficiency and low gas cost. On this same basis, Koppers - Totzek and Winkler have a lower rating. Lurgi, however, maintains its high position. Thus, the three processes that are outstanding in the overall evaluation are:

PROCESS	OVERALL EVALUATION RATING
(1) Lurgi	65
(2) HYGAS	64
(3) CO_2 Acceptor	60

6.0 Recommendation

The overall evaluation ratings for the three candidate processes are so close that it is difficult to make a definitive selection of a single process. Accordingly, to compare the viability of the processes, factors such as commercial maturity must be emphasized. The Lurgi process has been demonstrated on a commercial scale, and the HYGAS and CO_2 Acceptor processes have been demonstrated on a pilot scale.

Therefore, the Lurgi process is recommended because it is a commercially demonstrated, low-risk process with a high overall thermal efficiency and low gas cost.

6.0 Recommendation (Cont'd.)

As an alternate selection, HYGAS, a second generation process, is recommended because of its high overall thermal efficiency and low gas cost.

The CO_2 Acceptor process is recommended as an alternate second generation process if conditions beyond those considered in this report would require an alternate selection.

7.0 Support Work

The following organizations contributed to this study:

- Avco Corporation prepared a report covering the energy requirements of Montana, the coal availability in Montana and a study of federal support programs for financial assistance.
- American Lurgi Corporation prepared a study for the applicability of Lurgi gasifiers, with the same basis of feed coal and capacity used in this report.
- The Lummus Company utilized the American Lurgi data to prepare a technical and economic definition of a grass roots plant.

7.0 Support Work (Cont'd.)

- Morrison - Maierle, Inc., prepared an environmental report on the federal, state and local emission standards as applicable to Glasgow, Montana.

Information and data in these reports were used where required for the process selection study. The reports are included in the Appendix of the main report.

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SUMMARY OF EVALUATION

	BABCOCK & WILCOX	CO_2 ACCEPTOR	COGAS	HYGAS	KOPPERS-TOTZEK	TEXACO	WINKLER	LURGI
Raw Coal, TPD	21,614	17,946	29,600	21,434	23,079	22,029	22,603	22,425 ***
Oxygen, TPD	11,622	--	--	2,229	11,736	10,318	5,266	3,590 ***
Raw Water, GPM	19,476	5,847	14,689	7,121	18,189	17,356	17,877	6,080 ***
Purchased Electric Power,KW	297,200	90,100	48,700	91,200	435,200	120,500	189,900	58,000 ***
Total Plant Investment,$MM	807.8	469.8	740.9	454.6	874.6	746.6	697.2	500.0 *
Gas Cost, $/MM BTU	5.55	3.08	4.13	2.62	5.89	4.79	4.73	3.11
Overall Thermal Efficiency,%	44.7	64.8	58.1	69.8	42.2	52.0	50.8	60.1**
Technical Evaluation Ratings (Top Rating = 75)	55	45	43	45	70	42	65	72
Overall Evaluation Ratings (Top Rating = 80)	44	60	51	64	46	48	55	65

* Value derived by deleting the NH_3 synthesis section from the Lummus Estimate.

** Value derived from Lummus Estimate by substituting for purchased power a coal equivalent of 10,000 BTU/KWH instead of heat equivalent of 3413 BTU/KWH.

*** Lurgi/Lummus Estimate